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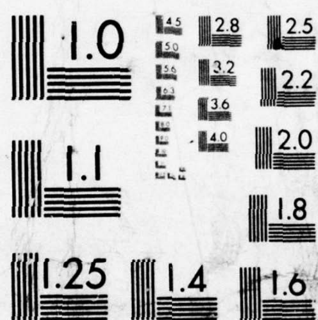

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INDIVIDUAL STUDY PROGRAM

ELECTROMAGNETIC COMPATIBILITY:
THE
PROGRAM MANAGER'S CONSIDERATIONS

STUDY PROJECT REPORT
PMC 77-1

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ELECTROMAGNETIC COMPATIBILITY:

THE

PROGRAM MANAGER'S CONSIDERATIONS

Individual Study Program

Study Project Report

Prepared as a Formal Report

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by

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE:

ELECTROMAGNETIC COMPATIBILITY: THE PROGRAM MANAGER'S CONSIDERATIONS

STUDY PROJECT GOALS:

To identify and examine: the implications of EMC requirements, current policies and directives concerning EMC, and current EMC planning techniques for EM system acquisition.

STUDY REPORT ABSTRACT:

Electromagnetic compatibility (EMC) is the ability of electromagnetic (EM) systems to operate in their intended environment without causing unacceptable degradation due to unwanted radiation or response. The program manager developing an EM system must be aware of EMC policies, requirements and planning techniques. This study project included research of current Federal, DoD and service policies and interviews with members of the Electromagnetic Compatibility Analysis Center (ECAC), Annapolis, MD. The requirement for early consideration of EMC in system planning is a recurring theme throughout the literature surveyed. A current EMC planning technique for managers is the development of an EMC Life Cycle System Management Model which identifies EMC actions and decisions required of a program manager during system acquisition. The three fundamental EMC planning factors of system technical characteristics, environmental geometry, and frequency assignments are described. These planning factors form the basis for trade-offs by the program manager to achieve EMC. Technical assistance for EMC is available from ECAC.

KEY WORDS: ELECTROMAGNETIC COMPATIBILITY
FREQUENCY
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EXECUTIVE SUMMARY

Electromagnetic compatibility (EMC) is the ability of electromagnetic systems to operate in their intended environment without causing unacceptable degradation due to unwanted electromagnetic radiation or response. Since electromagnetic radiations may travel worldwide, international regulations of treaty status have been established between the United States and 150 other countries. Supplementing these agreements are Federal regulations and policies. The Department of Defense has directed in DODD 3222.3 that an Electromagnetic Compatibility Program (EMCP) be established in all services to control interference.

The system acquisition program manager can promote EMC through built-in design compatibility. The three factors which may be used to control EMC are system technical characteristics, environmental geometry and frequency assignments. The program manager can design his system to an acceptable level of EMC by manipulating these three factors within the constraints of established standards, policies and operational mission requirements. EMC design techniques are most economical when applied early in the development of a system.

To assist the program manager with EMC design, this report presents and discusses EMC decisions and actions required throughout the acquisition process. A Life Cycle System Management Model is used to indicate the relationships of EMC actions to the system acquisition process. The Electromagnetic Compatibility Analysis Center, described herein, can provide technical assistance to the program manager upon request. A knowledge of EMC design requirements and policy by the program manager is an excellent starting point for ensuring electromagnetic compatibility.

TABLE OF CONTENTS

SECTION I

INTRODUCTION

Often it must appear to the acquisition program manager that the early-on or front-end considerations in his program are endless. The compendium of things to do grows by leaps and bounds in the conceptual and preconceptual stages, and each item of interest vies for his attention. One such contender is Electromagnetic Compatibility (EMC).

Most program managers equate EMC to a "black box" technology which engineers quote frequently, but which is an adjunct rather than an essential feature of his program. EMC is, of course, a prime consideration in communications-electronics (C-E) systems, but also it is a responsibility of all system designers and managers if successful operation of electromagnetic (EM) systems is to be assured.

> Electromagnetic Compatibility is the ability of communications-electronics equipments, subsystems, and systems, together with electromechanical devices (for example, vehicles, engine generators and electrical tools), to operate in their intended operational environments without suffering or causing unacceptable degradation because of unwanted electromagnetic radiation or response. EMC embraces both susceptibility and vulnerability.[1]

Thus, the considerations of EMC for the program manager center around the interactions of all electromagnetic systems, the exchanges of electromagnetic energy, and the steps which must be taken to minimize both the interactions and their disruptive effects. To assist the program manager fifteen EMC considerations or guidance categories have been identified for EMC planning. Also, fifteen actions and decisions in planning for EMC during system acquisition have been identified and discussed

1. Footnotes will be found on page 25.

in Section IV of this report. These EMC actions, decisions and guidance categories have been keyed to events in a Life Cycle System Management Model (LCSMM) in Appendix I. This method of EMC planning is used at the Electromagnetic Compatibility Analysis Center (ECAC), Annapolis, Maryland, and has been expanded in greater detail in DA Pamphlet 11-12, Integrated EM Analysis and Testing Guide, now under preparation at ECAC.

Purpose of the Study Project

The primary purpose of this study project is to alert acquisition program managers to the requirement for early-on consideration of EMC. It serves as an introduction to the methodology of EMC planning utilizing an EMC Life Cycle System Management Model (LCSMM). This project will indicate and discuss EMC decision points throughout the LCSMM. A guide to current regulations, directives and policy concerning EMC will be provided as a basis from which program managers may expand their understanding of EMC.

Specific Goals of the Project

For the program manager to have a successful program, he must adequately deal with all factors which impinge upon his program. This implies an ability to recognize important areas for consideration. Having identified EMC as such an area, the program manager asks many questions. What is EMC and what are its implications upon the system being considered? Who has developed an EMC policy, and what is its nature? Where can the program manager find assistance in EMC planning, and where does it enter into the Life Cycle System Management Model?

These are some of the specific questions to be examined in this study project.

Scope of the Study Project

Integral with EMC is the topic of electromagnetic spectrum (EMS) management. EMS management policy and decisions precipitate from the International Telecommunications Union (ITU), through the Office of Telecommunications Policy (OTP) and the Department of Defense (DoD), to the service departments and subordinate commands. Within the scope of this study project the constraints applied by these organizations will be accepted as unalterable by the program manager. Additionally, the techniques of EMS management will not be detailed in this project.

Standards and specifications and the engineering design responsibility for EMC are detailed in MIL-STD-188, -449, -461, -462, -463, and -469; however, an indepth treatment of these publications is beyond the scope of this study project.

SECTION II

ELECTROMAGNETIC COMPATIBILITY

Description of EMC

EMC, as defined in Section I, is achieved when all equipment capable of transmitting and receiving electromagnetic energy can operate satisfactorily in the same environment. This does not mean that interference will not occur, but that the resulting interference is within some level of tolerance. Operating EM equipment without suffering or causing unacceptable degradation is achieved through the consideration of three primary EMC factors: system technical characteristics, environmental geometry, and frequency assignments. EMC planning by the program manager during system acquisition involves compromise or trade-off among these three factors. A system containing two electromagnetic sub-systems whose technical characteristics allow unacceptable mutual interference may be corrected by manipulating the environmental geometry.

For example, assume a ship has a mechanically driven electrical generator which interferes with a communication radio. The technical characteristics of these two sub-systems can be altered by using filters, supressors or circuit redesign. Also, the environmental geometry can be altered by moving or separating the generator wiring from the radio wiring, maximizing the separation of the generator and radio antenna, and/or adding metal shields, covers, or ducts. Other changes may also be made; however, any change will require additional time and dollars. In this example the program manager will trade-off technical characteristics and environmental geometry to achieve EMC. This trade-off is most readily accomplished during the early part of system design. In general, the

later in a program that EMC problems are discovered, the more costly will be the corrective action.

The electromagnetic environment is a product of all the emitters in a particular area. The contribution of each emitter depends upon its technical characteristics such as radiated power, type of modulation, radiated band width and the frequency or frequencies of operation. The degree of interference received will depend on the receiver's own characteristics such as selectivity, sensitivity and the type of modulation in use. The relative location of emitters and receptors also determines the electromagnetic environment and the degree of EMC. The location can be influenced by terrain, tactical deployment concept, and the design limitations of the equipment. Frequency management techniques for the allocation and assignment of frequencies and time schedules also contribute to developing the electromagnetic environment.

Sources of Interference

Interference in the electromagnetic environment can be caused from many sources. It is common to divide interference into two general subcategories: natural and man-made. Natural interference to EM systems can be caused by atmospheric, solar, and galactic noise. Atmospheric noise is caused by the build-up and discharge of static electricity. The static discharges may be large, such as lightning, or small unseen discharges from objects like aircraft, vehicles, buildings or antennas. Atmospheric noise causes abrupt fluctuations in EM systems and sharp crashes of sound in C-E equipment. Solar noise, usually affecting C-E systems, is caused by the sun and increases with sunspot or solar flare activity. It sounds like a background noise or "hash" on C-E systems.

Galactic noise is caused by all electromagnetic phenomenon in the galaxy. It is also a background noise and varies in intensity with frequency.

Man-made interference, as the term implies, is more likely to be experienced in industrial or densely populated areas. Man-made interference is divided into two general types: narrowband and wideband interference. Sources of narrowband interference, affecting a single frequency or small group of frequencies, are caused by inadequate geographical separation, propagation conditions, improper equipment adjustments, harmonics, intermodulation and crossmodulation. Wideband interference extends over a large number of frequencies. There are many sources such as powerlines, fluorescent lights, arc-welding equipment, vehicle ignitions, switches and relays, radar pulses and industrial equipment utilizing electromagnetic energy. Electronic warfare (EW) may also be considered a man-made noise, but it is not addressed in this project.[2]

The nature and sources of interference have been described here only as road signs for the program manager. An in-depth technical description is of interest to the program engineers; however, for the program manager to develop an awareness and appreciation for EMC, he too must be alerted to potential problem areas affecting EMC.

EMC by Design

During the development of EM equipment, design engineers insure EMC through the use of past experience in the form of military specifications and standards and through the test and evaluation of new concepts and designs. Conscious design effort to achieve EMC will help prevent the fielding of an unacceptable system. Redesign or retrofit of a deployed system is costly and in many cases may be impractical. Even prior to

deployment, failure to insure EMC early-on can result in program delays and additional costs when "backing up" to affect an EMC change. Every effort must be made during the conceptual and design phases to insure EMC through the use of state-of-the-art EMC technology and materials.

Advances in the state-of-the-art in integrated circuits and packaging techniques may allow the use of advanced circuit designs to enhance EMC while staying within weight, size and cost. In C-E systems improvements in modulation techniques or filter design may permit closer frequency usage and increased EMC. Research and development efforts for EM systems must include EMC as a consideration. This can be accomplished through an exchange of information in seminars and technical publications.

Engineering design handbooks are a source of reference for methods of accomplishing EMC in EM programs. Proven EMC techniques such as intermodulation interference charts allow the designer to incorporate known methods and avoid costly mistakes or wasted time in reinventing the known methods.

Mathematical and computer models can be used to make EMC evaluations during design. Alternative circuit designs can be examined without the need to construct a breadboard circuit thus realizing a savings in time. ECAC has the capability to model spectrum management, emission and susceptibility characteristics for C-E systems, filter circuit design, and environmental geometry. The use of these models is available to all DoD agencies and additional information is provided in Section III.

EMC Through Concepts and Doctrine

The concepts and doctrine for the employment of EM systems have their greatest effect on environmental geometry. The program manager must know

how the user will ultimately deploy his system if valid EMC decisions are to be made. Designing to meet every conceivable EMC problem is neither desirable nor economical. This can lead to unwanted complexity, increased size and weight, and unacceptable costs. The program manager must examine the concept of his system to determine where trade-offs of environmental geometry, technical specifications and frequency assignments for his system can be made.

The familiar questions of who, what, when, where, and how provide the first clues of where trade-offs can be made. Computer models and studies of tactical concepts will indicate probable deployment of EM systems and expected equipment and spectrum densities for a given environment. For example, in a joint forces amphibious operation a large number of land, sea and air EM and C-E systems not normally collocated would be required to operate with EMC. High-powered shipboard radar systems may be required to operate in the proximity of land based radar systems. Numerous single channel and multichannel C-E systems in various frequency bands will be in use. An analysis of the EMC environment for this scenario with the aid of computer models can predict interference potential and assist in spectrum management and equipment design. In the early stages of a program there will be little or no equipment that can be used to evaluate EMC and conducting large joint operations for EMC is costly. When expected missions are synthesized, managers have a less expensive means of evaluating EMC.

Training for EMC

EMC training can determine the success or failure of any EMC program. Training should be required for all personnel who design, develop, produce,

deploy, use and maintain EM systems. EMC techniques and the consequences of incompatibility must be known and understood in order to avoid degraded operational performance. This is especially true where the operator and service technician is concerned.

For example, a solid state HF receiver originally procured for isolated receiving sites for the Army and Air Force was designed for operation in low energy radio frequency (RF) fields. A subsequent requirement caused many of these receivers to be installed in tactical mobile shelters where transmitters generating high RF fields were operating. Simultaneous operation of the transmitters and receivers caused the receiver RF input stages to be damaged. Automatic sequencing equipment was not available, thus requiring the operator to be trained to provide the EMC necessary to insure proper operation. A poor initial EMC training program resulted in an extremely high failure rate for the HF receivers. In some units the failure rate reached critical proportions before the consequences of EMC training were understood. In fact, one might even say that EMC was not properly considered in the original decision to relocate the receivers in the first place.

One solution for the program manager developing a C-E system is to include EMC doctrine in the technical manuals for his system. These technical publications should address operation and maintenance functions required to insure EMC. They will serve as a basis for EMC training when the system is deployed.

SECTION III

POLICY AND DIRECTIVES

International Regulation

The propagation of radio waves is not restrained by political borders; therefore, national policy and directives for controlling the use of the frequency spectrum, location of emitters and C-E system technical characteristics must conform to an international framework. The requirements of compatibility and interoperability[3] are vital if military C-E systems are to be deployed worldwide. Allied joint commands, such as NATO, require established standards for EMC during both war and peacetime.

The International Telecommunications Union (ITU), first created in 1865 and now a specialized agency of the United Nations, has a membership of about 150 countries. The ITU establishes International Radio Regulations which specify allocations of RF spectrum and registration of frequency assignments. The ITU Radio Regulations have treaty status when ratified by member nations. The ITU Radio Regulations, as amended in 1971, have been ratified by the U. S. Congress and have been in effect since 1 January 1973.

The actual allocation of the RF spectrum is done through World Administrative Radio Conferences (WARC) of the ITU. The last WARC to deal with the complete set of ITU Radio Regulations, a general WARC, was held in 1959. The next WARC for this purpose is scheduled for May 1979 in Geneva, Switzerland. Members of the Department of Defense (DoD) are now preparing to represent military interests at the Conference.

National Regulation

The utilization of RF spectrum, a natural resource, and the control of geographical location of emitters and establishment of technical standards is accomplished at a national level within the framework of the ITU Radio Regulations. The basis for this management is derived principally from the Communications Act of 1934. This act established the Federal Communications Commission (FCC) to regulate nongovernment communications and recognized the Constitutional powers of the President to regulate Government (and thus military) communications. The President, by Executive Order in 1970, provided for a Director of Telecommunications and established the Office of Telecommunications Policy (OTP) to accomplish governmental regulation. Thus, within the U. S., there is a dual authority for RF spectrum management - the FCC and the OTP.

An Interdepartmental Radio Advisory Committee (IRAC) was created to support and advise the Director of the OTP in managing government use of the RF spectrum. The IRAC is composed of representatives of the Departments of the Army, Navy and Air Force, as well as the Departments of Commerce, Interior, Justice, State and others. The FCC is not a member of IRAC; however, a liaison representative does work with the IRAC. The IRAC allocates frequency bands and established technical standards, all of which promote EMC.

EMC Management in DoD

Spectrum management and EMC policies within DoD are the responsibility of the Director of Telecommunications and Command and Control Systems (DTACCS). The DTACCS coordinates the DoD interface with the IRAC and is

responsible for monitoring and reviewing policies, plans, programs and budgets for telecommunications within the DoD. The DTACCS is a member of the Defense System Acquisition Review Council (DSARC), a matter of interest to the program manager of a C-E system.

The DoD has established policies and standards which are of concern to a program manager in the area of EMC and a list of those DoD Directives (DODD) is located in the Bibliography. Of particular interest is DODD 3222.3, Department of Defense Electromagnetic Compatibility Program (EMCP), dated 5 July 1967. This DODD established an integrated DoD program whose objectives are:

> A. Achievement of electromagnetic compatibility of all electronic and electrical equipments, sub-systems and systems, produced and operated by components of the Department of Defense, in any electromagnetic environment. Operational compatibility is part of the paramount focus of this objective.
>
> B. Attainment of built-in design compatibility rather than use of after-the-fact remedial measures.
>
> C. Fostering of common DoD-wide philosophies, approaches and techniques in the design, production, test and operation of C-E equipments.[4]

The DoD EMCP includes, but is not limited to, the following:

1. Standards and Specifications (Navy)[5]
2. Measurement Techniques and Instrumentation (Army)
3. Education for EMC (All services)
4. Data Base and Analysis Capability (Air Force)
5. Design (All services)
6. Concepts and Doctrine (JCS)
7. Operational Problems (JCS)
8. Test and Validation (Army)

DODD 4630.5, Compatibility and Commonality of Equipment for Tactical Command and Control, and Communications, dated 28 January 1967, was written to ensure that C-E systems "possess...compatibility and commonality essential for joint military operations."

It is apparent that the program manager is not without guidance in the realm of EMC. The need for EMC has been recognized; information and formal programs are available to the program manager. Each component service has published implementing regulations and technical guidance to assist in achieving EMC. The Bibliography contains a list of those considered most important to the program manager.

Electromagnetic Compatibility Analysis Center

DODD 5160.57, Electromagnetic Compatibility Analysis Center (ECAC), dated 23 September 1966, established the ECAC with the responsibility of analyzing and assisting with EMC problems through the use of a comprehensive data base and engineering techniques. Located in Annapolis, Maryland, ECAC is a contractor-operated facility managed by military and civilian personnel. ECAC can assist material developers in the areas of (1) Spectrum Planning, (2) Emission and Susceptibility Characteristics Evaluation, (3) Deployment and Siting Analysis, and (4) Consultation Services. ECAC maintains a comprehensive data base, a large-scale computer with appropriate software systems for analysis and data manipulation, and an extensive library of analytical techniques. Each component service is represented by a Deputy Director at ECAC and may be reached by writing to ECAC, North Severn, Annapolis, MD 21402. Telephone numbers at ECAC are: commercial, 301-267-extension; AUTOVON, 281-extension; IDS, 1229-extension. Extensions: Army, 2103; Air Force, 2681; Navy, 2556; Marine Corps, 2555.

SECTION IV

LCSMM FOR EMC

The Acquisition Process

Department of Defense Directive 5000.1, Major System Acquisition, dated 18 January 1977, outlines the DoD management policy for major system acquisitions as a sequence of specified phases of program activity and decision events initiated with approval of a mission need and extending through successful completion of development, production and deployment of the system. As a tool to assist in this process, a Life Cycle System Management Model (LCSMM) outlining the life cycle of system acquisition from materiel concept investigation to ultimate phase out and disposal of systems has been constructed. The LCSMM is a flow chart which may be used for both major and non-major systems. Appendix I, the LCSMM for Army system acquisition, will be used to illustrate the EMC considerations in system acquisition.[6] Similar events occur in the Air Force and Navy.

The basic events of decision-making, documenting and testing are shown on the top portion of the model. The EMC Decisions/Actions and EMC Guidance Categories are shown in the lower portion. The flow chart is event-oriented and has not been drawn to represent a time scale. Many of the events shown are only required for the most complex, costly or highly visible systems; however, the EMC decision points should be addressed for every system. The complete LCSMM is divided into the four major acquisition phases of Conceptual, Demonstration and Validation, Full-Scale Engineering Development and Production and Deployment.

TABLE 1. EMC Decisions/Actions

1. Preliminary experimental RF allocation request
2. Preliminary equipment characteristics and frequency supportability determination
3. Updated experimental RF allocation request
4. Prototype specifications defined
5. Verify prototype performance
6. Developmental RF allocation request
7. Development specifications defined
8. Verify development performance
9. Approve equipment authorization documents and training methods
10. Operational RF allocation request
11. Initial production specifications defined
12. Verify initial production performance
13. Operational RF assignment request
14. Production specifications defined
15. Verify production equipment performance

TABLE 2. EMC Guidance Categories

1. System feasibility and performance requirements
2. Command and organizational principles
3. System operational factors
4. Economic assessment
5. Electromagnetic environment evaluation
6. Natural environment evaluation
7. Hazard evaluation
8. Equipment and performance characteristics
9. Conformance, waivers, standards, specifications
10. Spectrum signatures
11. Measures of system effectiveness
12. Site survey and selection
13. EMC training data
14. EW analysis
15. Threat evaluation

EMC Decisions/Actions

Currently under preparation at ECAC is a publication titled Integrated EM Analysis and Testing Guide to be designated DA Pamphlet 11-12. The purpose is to:

> ...provide primarily a clearer understanding of the overall program structure, of the primary factors inevitably involved in EMC compromises, and of how the major activities within program areas develop the support provided to system managers and system operators.[7]

Included in the draft are the fifteen EMC Decision/Actions listed in Table 1 and the fifteen EMC Guidance Categories listed in Table 2. Also included is an EMC LCSMM which was simplified for use in this project to the LCSMM in Appendix I. The following fifteen numbered paragraphs are a discussion of the fifteen EMC Decisions/Actions. The appropriate EMC Guidance Categories are indicated in the paragraph heading to identify general areas of consideration. Appendix I folds out to allow the reader to identify the portion of the system acquisition life cycle referred to in each paragraph. Each paragraph is a brief discussion intended to identify for the program manager the type of EMC activities which occur and should not be considered as a complete guide for his actions. The EMC LCSMM is a planning tool for the program manager.

(1) Preliminary RF experimental allocation request (EMC Guidance Categories 1, 3, 5, 14, 15). The first action by the program manager of a system that is an RF emitter is to initiate a request for experimental frequency allocations. An EM system not intended to be an emitter will not require an allocation; however, the program manager should consider collocated C-E systems for the possibility of unintentional EM radiation or reception.

An experimental frequency allocation request is made on DD Form 1494 to the appropriate DoD Area Frequency Coordinator (DODAFC). DODAFC responsibility is divided among the Army, Navy and Air Force; however limited authority has been delegated to local commands. The program manager should seek direction first from his local command. At this early conceptual stage development information may be very limited; however, in recognition of the dual system of frequency allocation and the time required to receive an assignment, failure to initiate an early request could result in a delay of equipment testing later in the program. Note that allocation is a setting aside of frequency bands for selected functions, while assignment is a granting of authority to use a portion of the frequency spectrum. Even though an appropriate allocation may presently exist for the C-E system under consideration, formal application through the DODAFC must be accomplished.

Development of the operational concept at this time will drive the system feasibility and performance requirements. Bringing the system technical characteristics to within the scope of the operational concept will allow evaluation of existing systems in determining their effectiveness in satisfying the operational mission. Trade-offs between manipulation of environmental geometry (deployment), system technical characteristics, and frequency allocation will be accomplished at this time.

(2) <u>Preliminary equipment characteristics and frequency supportability determination</u> (EMC Guidance Categories 1-8, 15). Special task forces and study groups examine the preliminary concepts to determine the feasibility of the system. The system technical characteristics and the extent of spectrum occupancy are examined in light of performance objectives. The force deployment, tactics and doctrine combined with

operational factors are considered, and an evaluation of system cost in relationship to performance is made. Equipments presently operating in the spectrum under consideration, background noise levels and man-made interference are evaluated. Terrain and meteorological factors in the deployment area are determined, and potential radiation hazards to personnel and to other EM systems in the area are evaluated. The technical feasibility in terms of the long-range threat must be considered.

Upon completion of these investigations and trade-offs, a preliminary written concept package in terms of equipment technical characteristics and frequency supportability is produced. This is then incorporated in a Decision Coordinating Paper (DCP) for major systems or a formal report for other than major systems for authorization to proceed with the EMC concept established.

(3) Updated experimental RF allocation (EMC Guidance Categories 1, 3, 5, 6, 8). The exact equipment characteristics and frequency usage determined in the report from (2) will allow the experimental RF allocation to be updated, if required. In many cases, development funds may be withheld until the allocation is received; therefore, the application for allocation should be closely monitored from this time onward. Non-radiating EM systems require no action at this point.

(4) Prototype specifications defined (EMC Guidance Categories 9, 11, 12). The demonstration and validation phase is initiated by a DSARC I approval (or equivalent for non-major programs). In preparing the contract Request for Proposal (RFP) for the system prototype equipment specifications must specify design goals for EMC. Appropriate military standards and specifications for EMC should be tailored for inclusion in the RFP. Some measures of system effectiveness for EMC must be defined in

the RFP for guidance to the bidders in evaluating the proposed system.

The competing proposals received from the bidders are evaluated in terms of technical characteristics and cost against the EMC criteria previously established. The relationship between EMC and operational capability, cost, radiation hazard, spectrum conservation and conformance to proposed equipment standards will determine the appropriateness of the systems proposed. Selection and contract award are then accomplished.

(5) Verify prototype performance (EMC Guidance Categories 5-11, 15). The results from operational and development tests will reveal the success or failure of EMC design efforts. Shielding, bonding, filtering and the like will have been used to the extent necessary to produce the desired level of EMC. Power density measurements against radiation hazards criteria will be performed to determine potential operating restrictions or design modification. Tests to determine compliance with military specifications of susceptibility and emission standards in MIL-STD 499 and MIL-STD 462 are performed and evaluated.

(6) Developmental RF allocation request (EMC Guidance Categories 1, 3, 5, 6, 8, 10, 12). The results from (5) have been finalized and definitive evaluations of EMC in relationship to the environment have been completed. Site survey and selection for additional testing or deployment is made. Equipment characteristics which determine interactions with other EM systems and thus frequency supportability are defined. These factors allow application for a developmental RF frequency allocation for C-E systems. This application is often a condition to the release of funds for Full-Scale Engineering Development (FSED) so it should be made as soon as possible.

(7) Development specifications defined (EMC Guidance Categories 3, 4, 7-9, 11, 15). The FSED phase is initiated by a DSARC II approval for major system acquisition. The development specifications used in the RFP for FSED contract award must, as for previous contracts, specify design goals for EMC. The considerations in (4) also apply to this decision area. Contract award results and FSED begins.

(8) Verify development performance (EMC Guidance Categories 5-11, 15). The results from operational and developmental testing are verified as in (5). This evaluation completes verification of development equipment performance and the results will be used to determine if the system enters into production.

(9) Approve equipment authorization documents and training material (EMC Guidance Category 13). During FSED the requirement for technical publications and training programs for EMC is reviewed. Time must be allowed for publication and use of the material prior to the equipment being deployed. The equipment authorization documents are drafted and approved prior to deployment. Logistic support plans, ILS, can be affected by EMC in terms of susceptibility. Some systems require special logistic support to provide EMC while the system or components to the system are being transported. Completion of these actions is required prior to entering the production and deployment phase.

(10) Operational RF allocation request (EMC Guidance Categories 5, 6, 8, 10, 12). The operational allocation is an authority to produce or procure equipment which has passed the development stage and is planned for deployment. The application for allocation is also made on DD Form 1494. For a major C-E system, the form may have many attachments to

supply all required technical characteristics in precise detail. Operational RF allocations may be required for some radiating EM systems.

(11) Initial production specifications defined (EMC Guidance Categories 3, 4, 7-9, 11). As in EMC Decision/Action areas (4) and (7), the system specifications obtained from FSED pertaining to EMC must be communicated accurately in the RFP and then utilized to evaluate proposals and to award a contract for production. EMC requirements must be detailed and specific.

(12) Verify initial production performance (EMC Guidance Categories 5-12, 14, 15). The tests performed on production items are conducted in the same manner as in (5) and (8). These results insure EMC of the production items and allow the system to be released for deployment.

(13) Operational RF assignment request (EMC Guidance Categories 5, 6, 8, 10, 12, 14). The authority to operate on specific frequencies at specific locations is obtained through an *operational assignment*. The request procedure varies among services and may not be a function of the program manager depending on the type of C-E system involved. Assignments for fixed C-E systems will most likely be the responsibility of the program manager while tactical assignments will be the responsibility of using commands. Requests for operational RF assignments are processed through DoD Area Frequency Coordinators and ultimately to the Frequency Assignment Subcommittee of the IRAC.

(14) Production specifications defined (EMC Guidance Categories 3, 4, 7-9, 11). The initial production specifications (11), and production specifications (14), decisions and actions may be coincident depending on the method of procurement. The EMC considerations of previous RFP and contract award actions apply.

(15) Verify production equipment performance (EMC Guidance Categories 5-12, 14, 15). As in all previous EMC performance verification tests (5), (8), and (12), the results determine continued production deployment of the system. Operational problems will be evaluated to determine compliance with any existing waivers of EMC standards and specifications. The verifying of production equipment is a continuing process through the remainder of the system life. The performance data collected will be used for revision of training programs and technical data, modifications and product improvements, and determination of requirements for new replacement EM systems thus initiating a repeat of the LCSMM.

SECTION V

SUMMARY AND CONCLUSIONS

The acquisition program manager for EM systems has a responsibility to ensure EMC for his system. DoD policies and directives outline the objectives of EMC, technical specifications and standards set the goals for EMC, and ECAC provides technical assistance for the program manager.

Retrofitting of systems that experience unacceptable EMC can be costly. Thorough consideration of a system design in terms of EMC throughout the acquisition process will reduce the need for remedial measures after the system has been fielded. The program manager can influence EMC through the system technical specifications, the choice of operating frequencies, and the environment in which the system is utilized. A tool to accomplish EMC is the EMC Life Cycle System Management Model which identifies EMC decisions and actions for a program manager.

FOOTNOTES

1. Army Regulation 11-13, Army Electromagnetic Compatibility Program, 29 July 1969, pg. 1-1.

2. The EW threat and electronic counter-countermeasures (ECCM) are an important concern of the program manager. They will be considered as a subset of EMC in this report and will not be examined in detail.

3. Interoperability is the ability of C-E systems of different origin to exchange data (including speech) without the requirement of buffering, translative or similar interface devices.

4. Department of Defense Directive 3222.2, Department of Defense Electromagnetic Compatibility Program, 5 July 1967, pg. 2.

5. Service component or activity responsible for each EMCP category is as indicated.

6. Department of the Army Pamphlet 11-25, Life Cycle Management Model for Army Systems, May 1975, Figure C-1, modified by the author.

7. Development of the Army EMC Program Guide, ECAC-PR-76-058, October 1976, pg. 1. This publication available only by request to ECAC.

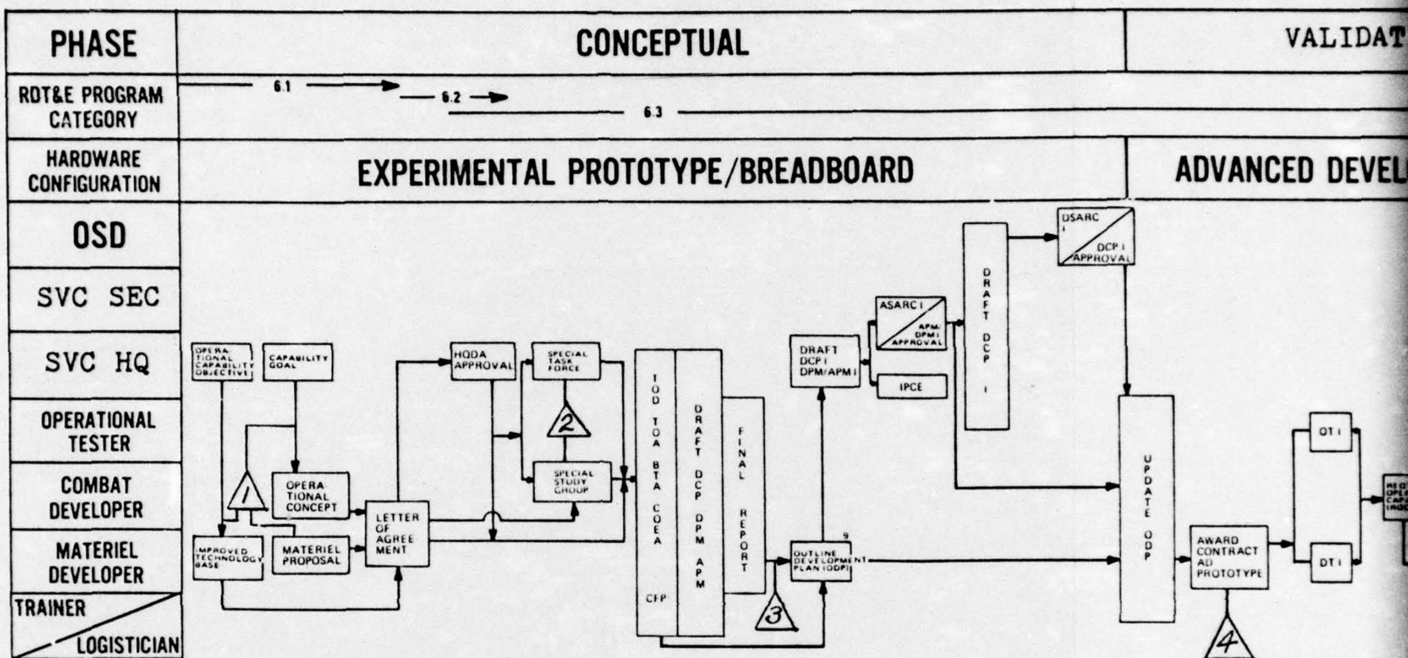

TABLE 1. EMC Decisions/Actions

1. Preliminary experimental RF allocation request
2. Preliminary equipment characteristics and frequency supportability determination
3. Updated experimental RF allocation request
4. Prototype specifications defined
5. Verify prototype performance
6. Developmental RF allocation request
7. Development specifications defined
8. Verify development performance
9. Approve equipment authorization documents and training methods
10. Operational RF allocation request
11. Initial production specifications defined
12. Verify initial production performance
13. Operational RF assignment request
14. Production specifications defined
15. Verify production equipment performance

2

EMC

LIFE CYCLE SYSTEM MANAGEMENT MODEL

VALIDATION AND DEMONSTRATION	FULL- SCALE ENGR DEVELOPMENT	
ADVANCED DEVELOPMENT PROTOTYPE/BRASSBOARD	ENGINEERING DEVELOPMENT PROTOTYPE	INITIAL PRODU

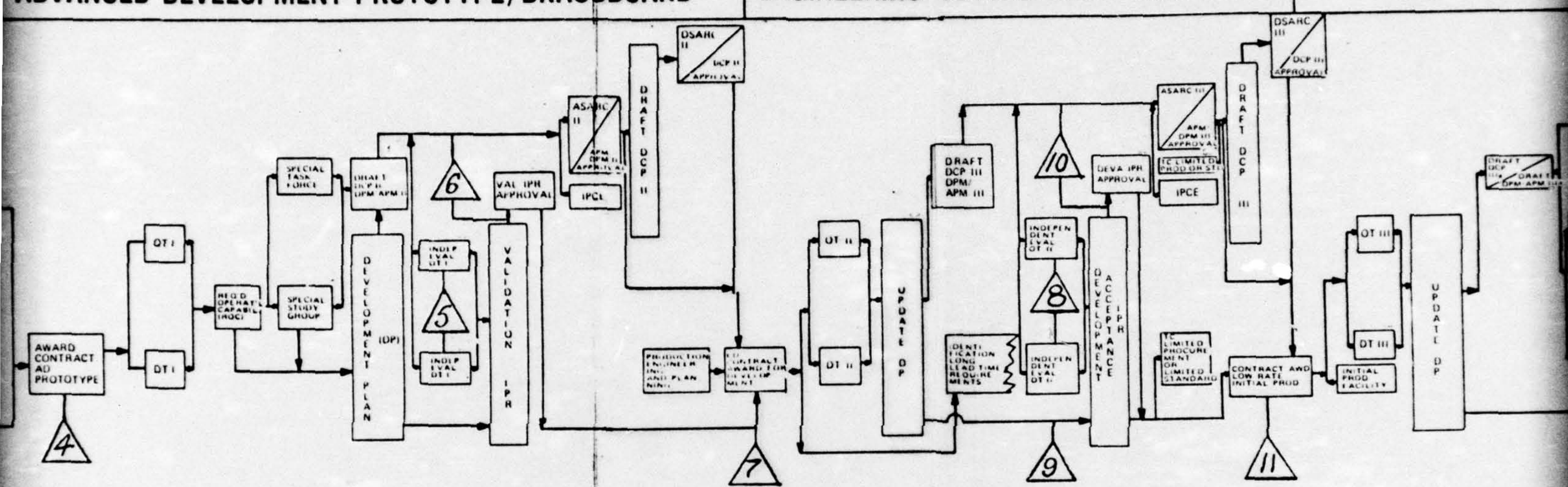

TABLE 2. EMC Guidanc

APPENDIX I

ADAPTED FROM DA PAM 11-25

1. System feasibility and per
2. Command and organizational
3. System operational factors
4. Economic assessment
5. Electromagnetic environmen
6. Natural environment evalua
7. Hazard evaluation
8. Equipment and performance
9. Conformance, waivers, sta
10. Spectrum signatures
11. Measures of system effecti
12. Site survey and selection
13. EMC training data
14. EW analysis
15. Threat evaluation

3

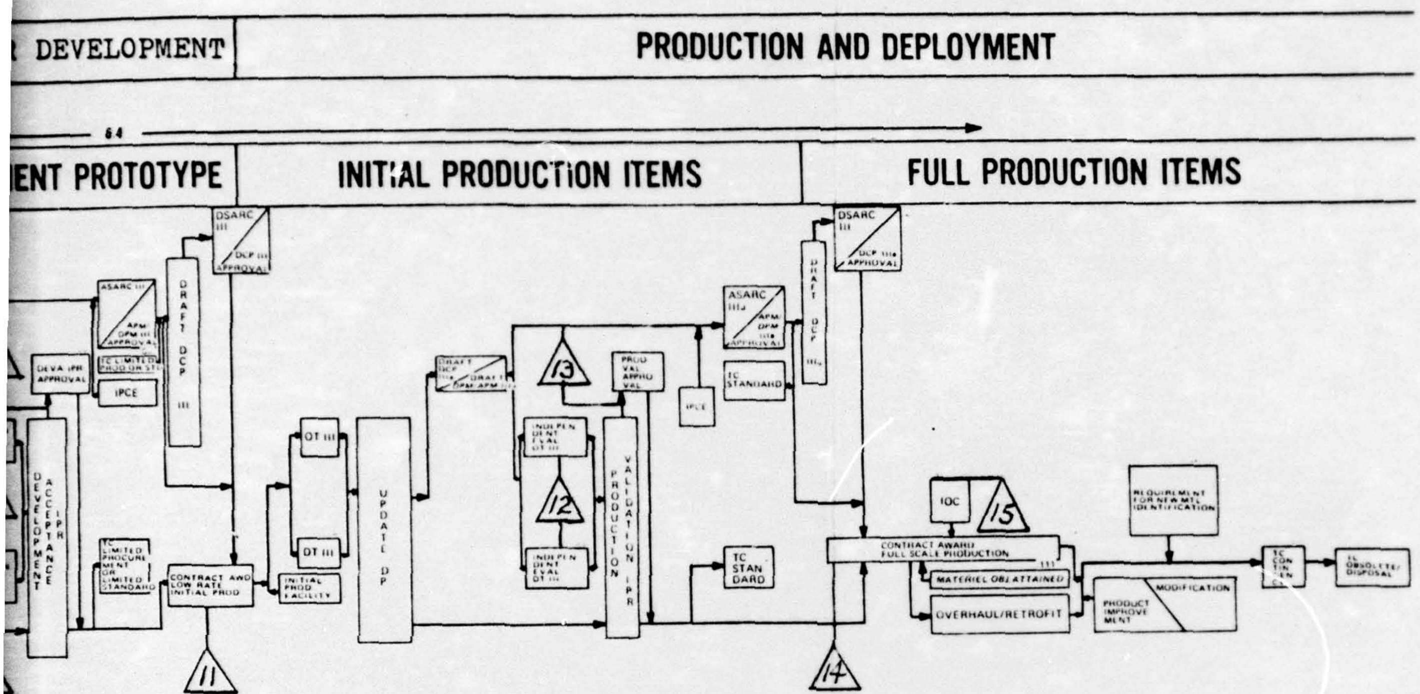

TABLE 2. EMC Guidance Categories

1. System feasibility and performance requirements
2. Command and organizational principles
3. System operational factors
4. Economic assessment
5. Electromagnetic environment evaluation
6. Natural environment evaluation
7. Hazard evaluation
8. Equipment and performance characteristics
9. Conformance, waivers, standards, specifications
10. Spectrum signatures
11. Measures of system effectiveness
12. Site survey and selection
13. EMC training data
14. EW analysis
15. Threat evaluation

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4. International Telecommunications Union Radio Regulations, Appendix I and Appendix IA, 1968, revised 1971 and 1974.

5. Office of Telecommunications Policy Manual of Regulations and Procedures for Radio Frequency Management, 22 September 1970, revised 1 January 1973.

6. DoD Directive 3222.2, Department of Defense Electromagnetic Compatibility Program, 5 July 1967.

7. DoD Directive 4630.1, Programming of Major Telecommunications Requirements, 24 April 1968.

8. DoD Directive 4630.5, Compatibility and Commonality of Equipment for Tactical Command and Control and Communications, 28 January 1967.

9. DoD Directive 4650.1, Management and Use of Radio Frequency Spectrum, 23 August 1966.

10. DoD Directive 5000.1, Acquisition of Major Defense Systems, 18 January 1977.

11. DoD Directive 5160.57, Electromagnetic Compatibility Analysis Center (ECAC), 27 September 1972.

12. Army Regulation 11-13, Army Electromagnetic Compatibility Program, 7 June 1974.

13. Army Regulation 105-16, Radio Frequency Allocations for Equipments Under Development, Production and Procurement, 20 December 1973.

14. Army Regulation 105-22, Telecommunications Requirements Planning, Developing and Processing, 22 February 1975.

15. Army Regulation 105-63, Army Electromagnetic Spectrum Usage Program, 18 December 1972.

16. Army Regulation 105-67, Electromagnetic Compatibility Program - Reporting of U.S. Military Electronic Equipment Environmental Data, 24 May 1968.

17. DA Pamphlet 11-12, Integrated EM Analysis and Testing Guide, under preparation.

18. DA Pamphlet 11-13, Army Electromagnetic Compatibility Program Guide, 10 March 1975.

19. DA Pamphlet 11-25, Life Cycle Management Model for Army Systems, 11 October 1968.

20. DA Pamphlet 105-2, Management of the Electromagnetic Spectrum, 6 July 1973.

21. Air Force Regulation 80-2, Documents Used in the Management of Air Force Research and Development, 12 May 1969.

22. Air Force Manual 100-31, Frequency Management and Electromagnetic Compatibility, 31 March 1970.

23. AFSC Design Handbook DH 1-4, Electromagnetic Compatibility, 5 June 1975.

24. AFSC Design Handbook DH 1-X, Checklist of General Design Criteria, 5 June 1975.

25. NAVAIR AD 1115, Electromagnetic Compatibility Design Guide.

26. NAVAIR 5335, Electromagnetic Compatibility Manual.

27. MIL-HDBK-237, Electromagnetic Compatibility/Interference Requirements Systems, 7 September 1967, Amendment 1, 5 July 1968.